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EMBRYOLOGY.[1]

Notes on Two Forms of Cestoid Embryos.—While engaged on the systematic study of the entozoa of marine fishes in the laboratory of the United States Fish Commission, Wood's Holl, Massachusetts, I have made notes and sketches of different stages of development of several species of Cestoidea. Without attempting at this time to give a detailed account of any one species, I wish to present a few notes on two forms which are of frequent occurrence.

To illustrate the first I have chosen a cyst taken from the peritoneum of the bluefish (*Pomatomus saltatrix*), and containing an embryo Rhynchobothrium. (Fig. 1.) Cysts like these, either of the same or closely related species, are abundant in most of the Teleostei, and are also occasionally found in Selachians. In the specimen under consideration the length was 12 mm., the breadth at the widest part 6 mm. When removed from its host the following points could be made out. The outer covering or cyst proper was oblong, larger at one end than the other, and tapering uniformly; thin, transparent, and delicate, with yellow granular patches, apparently masses of lymph-cells, on the surface at the larger end. When the cyst was broken open an endocyst (*blastocyst*, Diesing, " Revis. der Ceph. Ab. Param.," Introduction, p. 3) was released. After the escape of the endocyst from its enveloping cyst, the latter retained its shape and was not irritable or contractile. It was easily separable into a thicker outer and thinner inner layer, both hyaline and formed of connective tissue.

The endocyst when released from its capsular envelope was white and opaque, but became translucent, with a faint bluish tinge, when subjected to the action of the compressor and viewed by transmitted light. In form, while somewhat variable, it is usually club-shaped; much larger at one end than the other; the larger end blunt and rounded. The breadth of the larger end is uniform for about one-third the length of the endocyst, at which point there is a sudden constriction, beyond which the breadth diminishes gradually to the smaller end. When placed in sea-water it continues in a state of activity for hours. There is no decided locomotion, but a continuous series of movements, consisting of alternate contraction and extension of different parts of the sac-like mass and feeble lateral movements of the smaller end. In this condition the appearance of the endocyst is that of a thick-walled sac, the walls of which are made up of granular protoplasm with a thin investing membrane, and filled with clear, highly refractile globular masses. When placed under the compressor and slight pressure applied, the embryo Rhynchobothrium could be seen lying in a loose, irregular coil in

[1] Edited by Dr. John A. Ryder, Philadelphia.

the large end of the blastocyst. (Fig. 2.) A sinuous vessel, revealing the existence of a water vascular system, could be plainly seen extending along each edge of the blastocyst, apparently uniting in the median line at the smaller end. At the larger end they seem to be merged in the common parenchyma. In the immediate vicinity of the embryo the blastocyst is more transparent than in other parts, and the embryo seems to be held in position by a limiting membrane which lines the blastocyst and surrounds the embryo. When considerable pressure is applied the embryo is forced through the walls of the larger end of the blastocyst. The parenchyma is then seen to be confined to the thick walls of the blastocyst, as it does not flow out when the walls are ruptured. I succeeded in separating the wall of the blastocyst into two distinct coats, the outer one much thicker than the inner. In the outer coat three distinct layers were distinguishable; an outer granular layer, under which was a layer of longitudinal muscular fibres, and under this a thick layer in which were the characteristic refractile masses. These layers were not separable from each other. The thin inner coat, which was easily separable from the outer, was very delicate and contained a few irregular, flat, granular masses. The presence of transverse muscular fibres was not demonstrated, although their existence was shown by the power which the blastocyst had to contract and expand laterally. They probably lie in the outer granular layer.

The irritability and contractility of the blastocyst continue for several hours after the embryo is removed. In earlier stages of the development of similar forms, before the embryo is clearly outlined within the blastocyst, the individuality of the latter is even more clearly marked, and is strongly suggestive of the Sporocyst of a Trematode with the beginning of a Cercaria at one end. The endocyst or blastocyst may therefore be regarded as an intermediate or transition form, which is probably developed from a six-hooked larva, as in most other Cestoidea, and which, after the manner of a nurse, gives rise to an embryo by internal gemmation. This embryo, when ready to escape from the blastocyst, is a scolex similar in form to the adult, and if transferred to a proper host would develop directly into an adult strobile.

The embryo, when freed from the endocyst (Figs. 3, 3 *a*, and 4), was quite active, and consequently definitely accurate measurements of many of the dimensions were impossible. Its length was about 24 mm., although it was capable of varying this to a considerable degree both by contraction and extension. The bothria are two in number, marginal, oblong, widely divergent behind, approaching each other, but not uniting, in front; notched on the posterior border and obscurely two-lobed; edges free, thin, and mobile. Length of bothria, measured while somewhat flattened under the compressor, 2.23 mm.; breadth of head, com-

pressed, 2.72 mm. Proboscides, four, very long, slender, cylindrical, and armed with recurved hooks of different sizes. The proboscides were not entirely everted, but by counting the series of hooks which are exposed, and allowing for the part which is inverted, which can be plainly seen through the transparent walls of the proboscis, the result is about one hundred series of hooks arranged in spirals. The spirals are nearly 0.05 mm. apart, and the proboscides about 4.80 mm. in length. There are about fifteen longitudinal rows of hooks. These rows do not coincide exactly with the axis of the proboscis, but make about one and a half turns around it from base to apex. The hooks in these longitudinal rows present the following differences. (Fig. 6.) Three contiguous rows have small, recurved, stoutish hooks, which lie in groups of two, one hook immediately in front of the other, and each group of two thus formed corresponding in position with a single hook in each of the other longitudinal series. The central of these three rows does not have the hooks as distinctly placed in groups of two as the two remaining rows. At the bases of the proboscides these hooks are 0.0152 mm. in length, increasing to 0.02 mm. at the apex, with the breadth of base 0.0102 mm. throughout the series. On each side of this group of three longitudinal series lies a series of small, slender, slightly recurved hooks. These hooks are 0.0127 mm. in length at the base of the proboscis, increasing to 0.02 mm. at the apex, with the breadth of base 0.0076 mm. Each hook of these two series corresponds in position to one of the groups of two in the three series first mentioned. The remaining series of hooks are ten in number. It is rather difficult to estimate the exact number of these longitudinal series, since the transverse spirals are not in even curves, but have a slight zigzag or sinuous course, so that the exact number of longitudinal series in a given part of the circumference is not always plainly shown. In one proboscis I counted eleven of these series, but in another, of which I had a plainer view, there were certainly but ten. These hooks are much larger, stouter, and more sharply recurved than those in the other series. The length of one of the largest near the base of the proboscis was 0.0356 mm., with a breadth of base of 0.0254 mm. Towards the apex of the proboscis they are a little longer than this. These larger hooks are not of uniform size, those adjoining the smaller longitudinal series being smaller than those farthest from them. In the transverse spirals formed by these hooks there is a tendency to form two faintly-defined groups of three hooks and one of four, the hooks in these groups of course standing side by side.

The proboscis-sheaths (Fig. 4) are long and spiral. A contractile ligament was clearly defined in each and could be traced out into the proboscis, where it appeared as a tubular band containing a fluid in which floated a few granules. Towards the end

this tubular ligament merged imperceptibly into the proboscis, and the fluid interior with granules became the interior of the inverted proboscis, with, at first, small and scattered rod-like hooks, and towards the apex of the inverted proboscis, with normal hooks attached to the inner parietes.

The front end of the long and slender contractile bulbs lies about 10 mm. back of the apex of the head; length 2.46 mm.; breadth 0.24 mm. The contractile bulbs, as in all the Trypanorhyncha, are thick-walled. The walls are composed of diagonal muscular fibres, which interlace, making angles of about 70° and 110° with each other. These organs act in much the same manner as the bulb of a syringe. By their contraction the fluid contents is forced into the proboscis-sheaths and proboscides. The column of fluid thus forced into the proboscides causes them to unroll like the finger of a glove that has been turned in. The contractile ligament, noticed above, extends the entire length of the proboscis-sheath and is attached to the inner parietes of the bulb; by its contraction the proboscis is invaginated from the apex. When the embryo was first liberated the proboscides were entirely retracted; when, however, pressure was applied, they unrolled. In this condition the proboscides are very beautiful objects, being quite transparent, while the chitinous hooks have a brilliant vitreous lustre. When fully extended the proboscides throw themselves into graceful spiral curves. When the pressure is released they are apt to be withdrawn.

The bothria, in life, are transparent, finely granular, with a few scattered, refractile globular masses similar to those in the walls of the blastocyst. The tubular neck, when flattened under the compressor, presents the following features. The centre, surrounding the proboscis-sheaths and extending nearly to the edges, is filled with large, irregular granular masses closely packed together. Outside of this inner core is a layer of longitudinal muscles, and outside of this a layer of vascular tissue, in which the reticulated vessels of the water vascular system can be plainly seen. Outside of this again, and forming the outer coat of the neck, is a layer of dense tissue, which, as nearly as can be ascertained without stained sections, consists of transverse muscular fibres.

The water vascular system consists of a net-work of vessels in the borders of the bothria which connects with large sinuous vessels in the centre of the head, and together with these with the reticulated subcuticular vessels of the neck. Back of the contractile bulbs the system is represented by two pairs of vessels which lie in sinuous curves near each edge of the embryo. One of these vessels was much larger than the others, and ended in a bulbous enlargement.

Behind the contractile bulbs the body has the appearance of an elongated sac, filled with granular parenchyma, but with the

refractile masses much smaller than those in the blastocyst, and enclosed in an investing membrane about 0.005 mm. thick. The posterior end is terminated by a papillary, button-like process, which is retractile and covered with a dense coat of minute, straight, hair-like bristles. (Fig. 5.)

Another form of cyst I will notice briefly and illustrate by an embryo Tetrarhynchobothrium, taken from the surface of the liver of the cero (*Cybium regale*). (Fig. 7.) This cyst is long and slender, about 10.5 mm. in length and 1.5 mm. in breadth, yellowish, opaque, but broken in places so as to show the outline of the blastocyst.

The blastocyst, which is set free when the walls of the cyst are ruptured, is long and slender, with a neck-like constriction at one end. (Fig. 8.) The head part thus set off is very changeable in form, expanding, contracting, moving up and down and from side to side, and revolving with a rotary movement on the constricted neck. The longer part or body of the blastocyst also undergoes much change of form by irregular contraction and expansion, but these movements take place more slowly than in the head. The color is ivory-white, slightly translucent when extended.

When compressed the embryo is discovered lying in a coil in the head of the blastocyst. (Fig. 8.) The parenchyma of the head part is now seen to be much coarser than that of the body part, the coarseness being due to the presence of numbers of large, oval, refractile fluid spaces. The parenchyma of the body is dense and finely granular, with smaller refractile masses than those in the head part. When the head part of the blastocyst is broken open the embryo is released, but instead of separating from the blastocyst, as in the case of the embryo Rhynchobothrium, the blastocyst remains attached to the body of the scolex much like the Cystocercus of Tænia. The method of release, however, is quite different from that of the Cystocercus of most Tæniæ. Instead of unfolding like the finger of a glove, the neck of the scolex first emerges in the form of a loop. (Fig. 9.) While in this position the head lies close beside the base of the neck in the vicinity of the contractile bulbs. The head is released by a simple straightening of the neck, which at its base, a short distance back of the contractile bulbs, remains attached to the head part of the blastocyst. (Fig. 11.) In this specimen, after the head of the scolex was released, the anterior part or head of the blastocyst continued for some time working backwards and forwards on the neck of the scolex like a movable barrel on a stationary piston. (Fig. 10.) Considerable pressure was applied for the purpose of making the scolex separate entirely from the blastocyst, but without causing it to break loose. When pressed out as far as it would go, it could be seen that there was an unbroken continuity between the scolex and blasto-

cyst. The posterior tapering end of the scolex, however, was clothed with the straight, fine hair-like bristles noticed in the Rhynchobothrium embryo.

The bothria are four in number, in opposite, lateral pairs, spreading from the front of the head. They are quite mobile, sometimes with the sucking-disks turned forward, sometimes backward, and with a retractile proboscis, armed with long, slender, slightly recurved hooks, belonging to each bothrium. (Figs. 11 *a* and 11 *b*.) The proboscides were everted but a short distance, but they were apparently as fully developed as those in the Rhynchobothrium embryo. The proboscis-sheaths were in spirals and the contractile bulbs slender. A reticulated system of vessels in the margins of the bothria, and sinuous longitudinal vessels behind the contractile bulbs and near the edges of the blastocyst, were made out in the living specimen.

In a specimen which was lightly stained with carmine and placed in glycerine, the scolex and body part of the blastocyst are red, while the globular head-like part of the blastocyst is a golden yellow, the carmine only showing faintly in some longitudinal central vessels, which apparently belong to the water vascular system. This same part in unstained specimens in alcohol is yellowish and more opaque than the body, which is white with a faint bluish tinge.

The development of this form differs at this period from that of the Rhynchobothrium described, in that the blastocyst is retained as a part of the scolex after the latter is released. I have repeatedly tried the experiment of opening blastocysts of these two types, with the results in every case as given above. In the one case, the embryo does not seem to have any vital connection with the blastocyst when the walls of the latter are broken. In the other, the embryo cannot be removed from the blastocyst except by breaking a connecting bond. Whether, in the latter instance, the blastocyst becomes a part of the adult strobile by giving rise to segments by absorption or otherwise, or whether it is evanescent, I have, as yet, had no opportunity of observing. —*Edwin Linton, Wood's Holl, Mass.*, August 31, 1886.

EXPLANATION OF PLATE.

FIG. 1. Cyst from peritoneum of *Pomatomus saltatrix* containing endocyst, enlarged about two diameters.

FIG. 2. Endocyst released from its cyst, somewhat flattened under the compressor so as to show the embryo Rhynchobothrium coiled up in the larger end, enlarged about two diameters.

FIG. 3. Embryo liberated from the endocyst (or blastocyst), lateral view, enlarged three diameters.

FIG. 3 *a*. One of the bothria, isolated, enlarged three diameters.

FIG. 4. The same flattened under the compressor, showing the contractile bulbs, the spiral proboscis-sheaths, and the protruded proboscides, enlarged six diameters.

FIG. 5. Posterior end of same, showing the termination of the vessels of the water vascular system and the fine hair-like bristles on the terminal papilla, enlarged twenty-five diameters.

PLATE X.

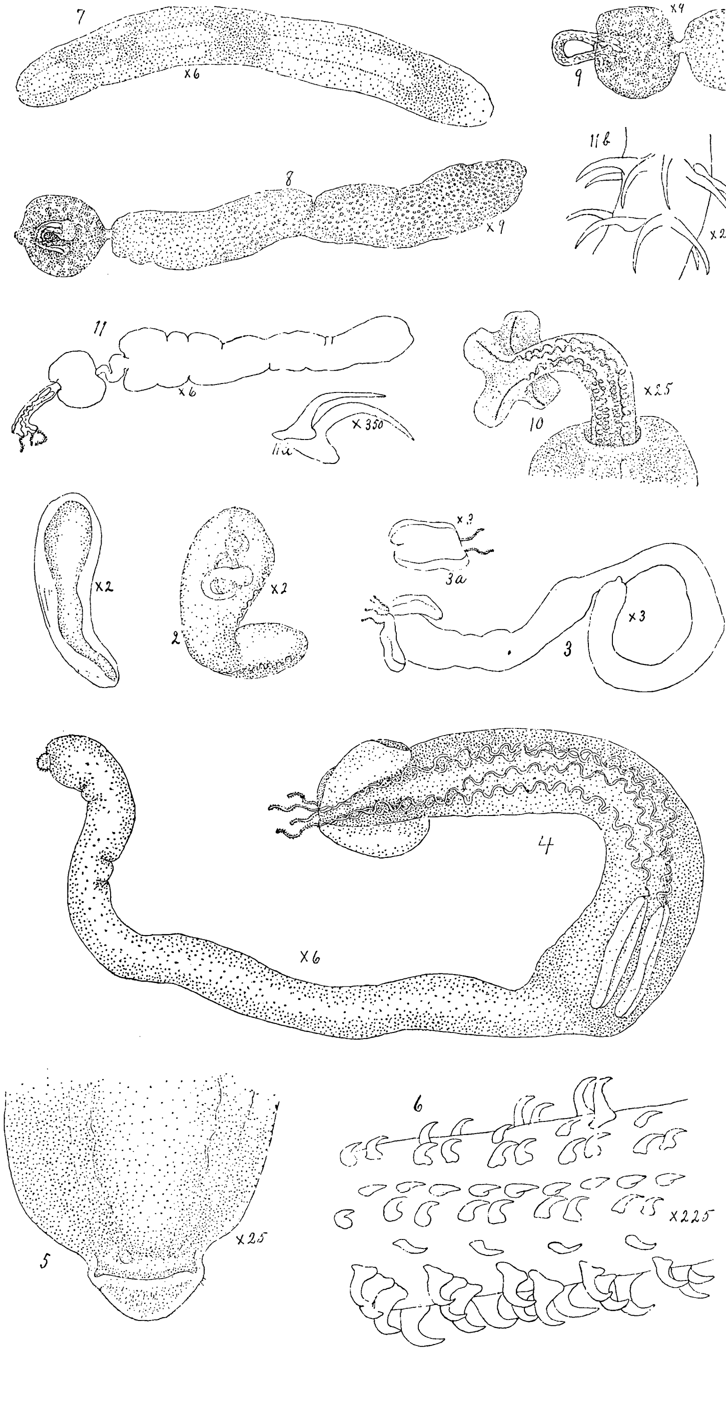
7
x6
9
x4
8
x9
11b
x225
11
x6
11a
x350
10
x25
x2
2
x2
3a
3
x3
4
x6
5
x25
6
x225

FIG. 6. Portion of proboscis, showing the five series of smaller hooks in front and a part of the larger hooks at the side, enlarged two hundred and twenty-five diameters.

FIG. 7. Cyst with endocyst, from surface of liver of *Cybium regale*, enlarged six diameters.

FIG. 8. Endocyst (blastocyst) liberated from its cyst, slightly compressed and showing the coiled embryo Tetrarhynchobothrium in the "head," enlarged nine diameters.

FIG. 9. The same, subjected to greater pressure, showing the embryo in the act of escaping from the blastocyst, enlarged nine diameters.

FIG. 10. The same, with head freed from the blastocyst, but still attached posteriorly to the "head" of the blastocyst. The bothria are seen from below as they are spread out and applied to the under glass of the compressor, enlarged twenty-five diameters.

FIG. 11. Outline of embryo with its blastocyst now attached like a rudimentary strobile, enlarged six diameters.

FIG. 11 *a*. Hooks near apex of proboscis, enlarged three hundred and fifty diameters.

FIG. 11 *b*. Portion of proboscis, enlarged two hundred and twenty-five diameters.

All the figures drawn from life by Mrs. Edwin Linton.

Edwin Linton.

Development of Scorpions.—Kowalevsky and Schulgin have a paper on the development of *Androctonus ornatus* in the *Biologisches Centralblatt* (vi. pp. 525–532, 1886) which throws much light on these forms. As long as the egg remains in the ovarium it is not impregnated. Segmentation begins in the uterus. Their earliest embryo had the blastoderm completely formed at one pole of the egg, and at this time no nuclei were to be seen in the yolk. The first appearance of a differentiation into germ-layers was seen in the appearance of a swelling beneath the blastoderm, the cells of which arise from the pre-existing blastoderm cells and sink to the lower layer. This germinal area is circular in outline. The next step consists in the formation of the embryonic envelopes, which arise as a circular duplicature of the blastoderm in a manner analogous to those of Hexapods. Now the germinal area elongates, and one pole (cephalic) retains its breadth while the other (abdominal) becomes thicker and longer. During these processes many cells separate from the lower layer (ento-mesodermal) cells and sink into the yolk. These cells are not regarded as forming any of the tissue of the scorpion, but as digesting or softening the yolk. The entoderm arises as a layer of cells which separate from the ento-mesodermal layer and come to lie close upon the yolk. These rapidly spread over the yolk, which has already been enclosed by the amnion and serosa. The entoderm cells modify the outer layer of the yolk and then take up the modified deutoplasm, at the same time taking on the character of a cylindrical epithelium. The abdomen now grows out, and a portion of the mesenteron extends into it as far as the penultimate segment, where it unites with the proctodeum. The central portion of the mesenteron is latest in being differentiated into the tubular mid-gut and the

lobulated liver. The neural surface is outlined first, then the sides and hæmal wall.

The mesoderm is first differentiated when the entoderm separates from the ento-mesodermal layer, but for a long time it lingers in the germinal area. It then segments, and there is a preoral segment which contains a cavity like those of the post-oral series. The somatopleure is thicker than the splanchnopleure. Beyond the cœlom these layers unite and extend themselves dorsally between ecto- and entoderm and the marginal cells, changing their character separate, and become the primary blood-corpuscles. They fill the space on the back of the embryo, which the authors regard as the homologue of the segmentation cavity. Later the mesodermal layers unite—first above and later below—in this cavity, thus forming the central circulatory organ. Both the endothelium and the muscularis of the heart are of mesodermal origin, and even before the union of the layers of either side the histological differentiation of endothelium and muscular layers is evident.

The first traces of the nervous system appear as ectodermal thickenings. In each segment appear, on either side, two elevations. Of these the lateral give rise to the appendages, the median to the ganglia. At first these latter are simple ectodermal thickenings, but soon a rapid process of cell-proliferation takes place—first in the cephalic, then in the body region—in the following manner. In the head there are from fifteen to twenty places, in the other segments from ten to twelve, where this growth takes place. Each has the appearance of a groove, and in section these grooves are seen to be simple cavities which soon disappear by the growth of the bounding cells. In this way a very rapid proliferation is possible, but the authors do not consider the point whether it have any phylogenetic importance. The development of the brain is distinguished from that of the rest of the nervous system in that an accessory fold takes part in its formation. This fold was previously recognized by Metschnikoff in the scorpion and by Balfour in the spiders; it is distinct from the grooves mentioned above. A groove is formed around the periphery of the procephalic lobes, which becomes deeper and finally forms a right and a left cerebral vesicle. Next a second fold arises and forms a pouch on either side, the mouths of which are directed laterally. These are the first traces of the median eyes. The lateral eyes are developed independently, but their history has not been worked out.

The coxal glands, when first seen, appeared as a pair of tubes opening externally at the base of the second (?) pair of feet. Later the tubes were much coiled. Two portions could be distinguished,—an inner, arising from the splanchnopleure and communicating with the cœlom by a broad funnel, and an outer, formed by an ectodermal invagination. The lung-sacs appeared

late, as simple inpushings into a space rich with blood-corpuscles.

In this connection the reader is referred to this journal, vols. xix. p. 560; xx. pp. 666, 825, and 862.—*J. S. K.*

Polar Globules in the Crustacea.—The question whether there are polar globules formed in the maturation of the arthropod egg has long remained in doubt, and both Minot and Balfour have suggested that their absence was connected with the existence of parthenogenesis. Several writers have described and figured what might be polar globules, but their observations have contained a considerable element of doubt. Recently, August Weismann (*Zool. Anzeiger*, ix. 570–573, 1886) gives a preliminary account of the studies in this direction made by himself and his pupil, Chiyomatsu Ishikawa, on the parthenogenetic eggs of several Crustacea. In *Polyphemus oculus*, the ripe summer egg forms a polar globule in the normal manner, with a spindelkern, the long axis of which is at right angles to the surface of the egg. Then the egg enters the brood space, and there quickly forms a vitelline membrane. While this is going on the spindle divides, and the polar globule, which contains considerable protoplasm, becomes separated from the egg. This takes place at the animal pole of the egg, and then the inner end of the spindle becomes converted into the segmentation nucleus, and segmentation quickly follows. At the close of the second segmentation the polar globule itself divides and then quickly disappears; the authors think it is absorbed again by the egg. In *Bythotrepes longimanus* the process is much the same, except that the transformation of the proximal end of the spindelkern into the segmentation nucleus has not been seen. At the eight-cell stage the remnants of the polar globules are still visible, sunk between the cells, but with further development of the egg they sink deeper and finally disappear. Grobben had described polar globules in *Moina paradoxa* and Weismann confirms the observation, describing the process of formation as witnessed in the living egg. It does not differ materially from that outlined in the other species. In Leptodora, Weismann found a body very like the polar globules of Polyphemus and Bythotrepes, but did not see the method of their formation. In *Daphnia longispina* the spindle is apparently not so evident as in other cases, but its place is taken by a clear spot about half-way between the pole and the equator. Shortly after this the polar globule appears on the surface, its nucleus frequently retaining traces of the karyokinetic figures of formation while its circular or oblong body remains homogeneous. During the first and second segmentation of the egg the polar globule itself divides, the process being accompanied by karyokinesis and the resulting cells remaining close together. In this species the egg

completely fills its envelopes, and hence the polar globules are forced into the soft surface of the yolk, where they are with difficulty visible, at least without reagents. Leydig's observations, a quarter of a century ago, on the eggs of this same species showed bodies which have been supposed to be polar globules; but this could not have been the case, as these bodies which he describes were *outside* the chorion. A full paper is promised in the *Verhandlungen* of the *Freiburg Gesellschaft.—J. S. K.*

ANTHROPOLOGY.

The Races of Men.—A. Hennuyer, of Paris, will publish a series of volumes entitled " Bibliothèque Ethnologique, Histoire Générale des Races humaines." The first volume has already appeared, with the title:

Introduction à l'Étude des Races humaines, by A. de Quatrefages. There will follow:

Les Races Noires, by E. T. Hamy.

Les Races Jaunes, by M. J. Montano.

Les Races Rouges, by Lucien Biart.

History of the Mongols, by Jules Denitar.

Les Foulahs, by Dr. Tautain.

Les Aztèques, by Lucien Biart.

M. Quatrefages perfects the scheme of nature which has already appeared in his work, entitled " L'Espèce humaine," but which may not be familiar to all the readers of the American Naturalist.

Empires.	Kingdoms.	Phenomena.	Causes.
Inorganic	Sidereal	Keplerian movement	Gravitation.
	Mineral	Keplerian movement plus physico-chemistry	Gravitation. Etherodynamics.
	Vegetal	Keplerian movement plus physico-chemistry plus vitality	Gravitation. Etherodynamics. Life.
	Animal	Keplerian movement plus physico-chemistry plus vitality plus voluntary motion	Gravitation. Etherodynamics. Life. Animal Spirit.
	Human	Keplerian movement plus physico-chemistry plus vitality plus voluntary motion plus morality and religiosity	Gravitation. Etherodynamics. Life. Animal Spirit. Human Spirit.

The views of monogenists and polygenists are presented in parallel columns, with monogenism as the personal equation of the author. It remains for a polygenist to prepare a similar table with as much fairness.

Monogenism.	Polygenism.
All men belong to one and the same *species*.	There are several *species* of men.
The differences which distinguish human groups are racial characters.	These differences are like specific characters.